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Release Benefits Hardwoods in Crowded Shelterbelts

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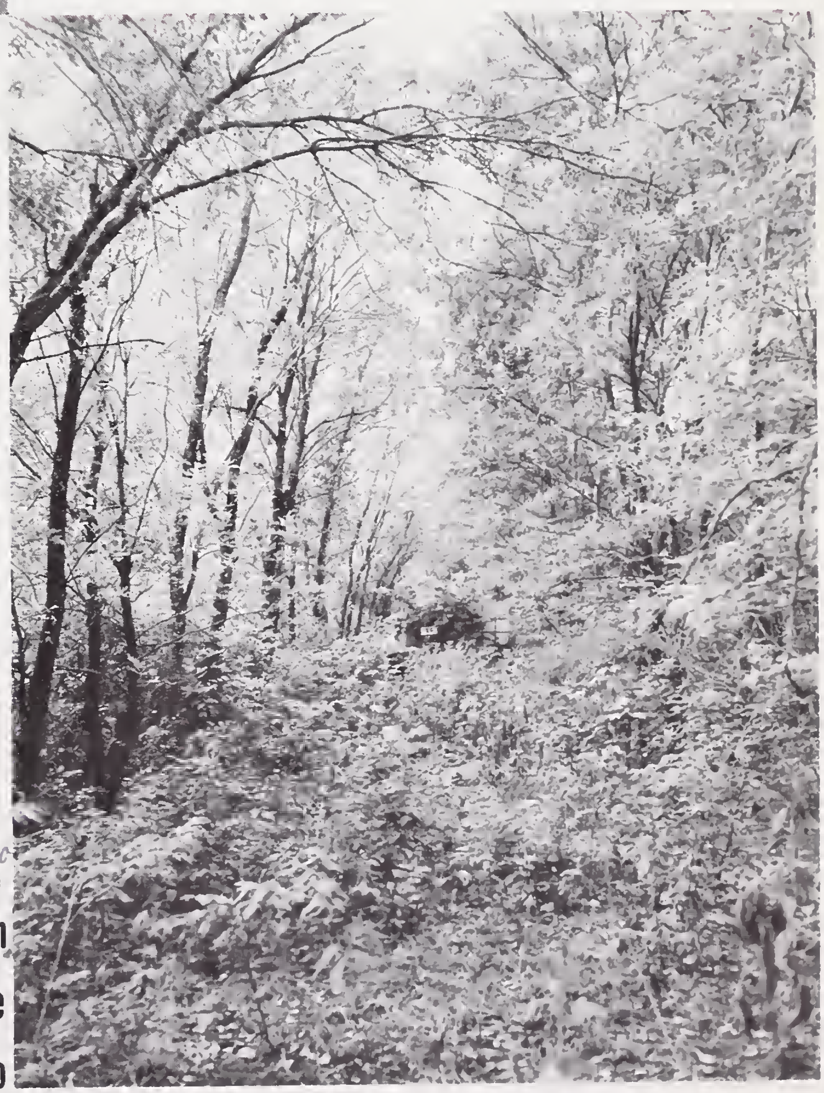

Rocky Mountain Forest and Range Experiment Station
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Release Benefits Hardwoods in Crowded Shelterbelts

by

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CONTENTS

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David F. Van Haverbeke and Charles E. Boldt

Introduction

Hardwood trees predominate in most multiple-row shelterbelts planted throughout the Great Plains in the late 1930's and early 1940's during the Prairie States Forestry Project. It is not unusual for 8 or 9 rows of a "standard" 10-row shelterbelt to consist of hardwood species.

Spacing between tree rows in these shelterbelts is usually 10 feet; within-row spacings for interior rows of hardwood trees are commonly 6 to 8 feet. Trees were purposely planted close to: (1) improve likelihood of adequate stocking, (2) hasten development of barrier density, and (3) favor early crown closure and thus eliminate the need for longtime cultivation (Olson and Stoeckeler 1935, U. S. Forest Service 1939). It was intended, however, that the closely spaced stands would be thinned later to maintain satisfactory growth and vigor.

In many areas of the Great Plains, these shelterbelts have developed vigorously and become heavily overstocked. Unfortunately, most shelterbelt owners have failed to make the planned thinnings. Slabaugh (1964) stated that the delay in thinning has been due, in part, to the reluctance of Plains dwellers to cut live trees for any reason and, in part, to a concern over possible adverse effects of thinning on shelterbelt effectiveness.

Trees in these crowded shelterbelts are characterized by poor foliage color, sparse and short crowns, suppression of slower growing species and individuals, and by a general slowdown of the growth processes in all but the dominant trees. These symptoms forecast a premature breakup and loss of shelterbelt effectiveness.

Timely, corrective treatment will be needed to restore vigor and extend the service life of these declining shelterbelts. The objective of this investigation was to find out how several species of hardwood trees, growing in heavily stocked shelterbelts, would respond to thinning.

Past Work

Caborn (1965) recognized two types of thinnings: "low-thinnings," to remove trees that have been overtopped and suppressed and leave a large number of well-grown trees from which to select the final stand; and "crown-thinnings," to reduce competition within the dominant classes. He recommended thinning to maintain a spacing of one-sixth of the average tree height for shade-tolerant species, about one-fifth of the height for less tolerant species, and a ratio of about one-fourth of the height for trees requiring much light.

Walker (1945) thinned prairie shelterbelts in Canada. He recommended thinning when branches are broken by wind, ice, and other weaknesses, when one species fails to compete with another, and when individual trees fail to compete within a species.

Van Haverbeke and Boldt (1968) released suppressed 20-year-old ponderosa pine and eastern redcedar from adjacent rows of Russian-olive and green ash trees in Nebraska shelterbelts. They found that release improved stem diameter growth, freed stem terminals from whipping and rubbing by adjacent rows of hardwood trees for uninterrupted height growth, and greatly increased foliage density—thus enhancing the vigor of individual trees and increasing the effectiveness of the shelterbelts as a whole. They also reported on the development and management of sprouts arising from stumps of cut hardwood trees in the rows adjacent to the pine and cedar.

In drier areas, however, the responses to thinning have apparently been less promising. Preston and Brandon (1946) reported a reduction in mortality but a lack of response in height and diameter growth when thinnings doubled the spacings between 16- to 18-year-old ponderosa and Austrian pines in a northeastern Colorado shelterbelt. Also, row thinning apparently had no beneficial effect on the survival and growth of green ash over a 10-year period in Montana where the 20-year-old ash was released by cutting caragana and Siberian elm in adjacent rows (U. S. Bur. Plant Ind., Soils and Agr. Eng., 1945).

Walker (1945), Ermolenko (1963), and Bodrov and Jarosenko (1963) cautioned against weed, grass, and herbaceous invasion of shelterbelts after thinning. The detrimental effects of such vegetation on the growth and development of shelterbelt trees is indicated, in part, by the work of Phipps (1963). He found marked responses

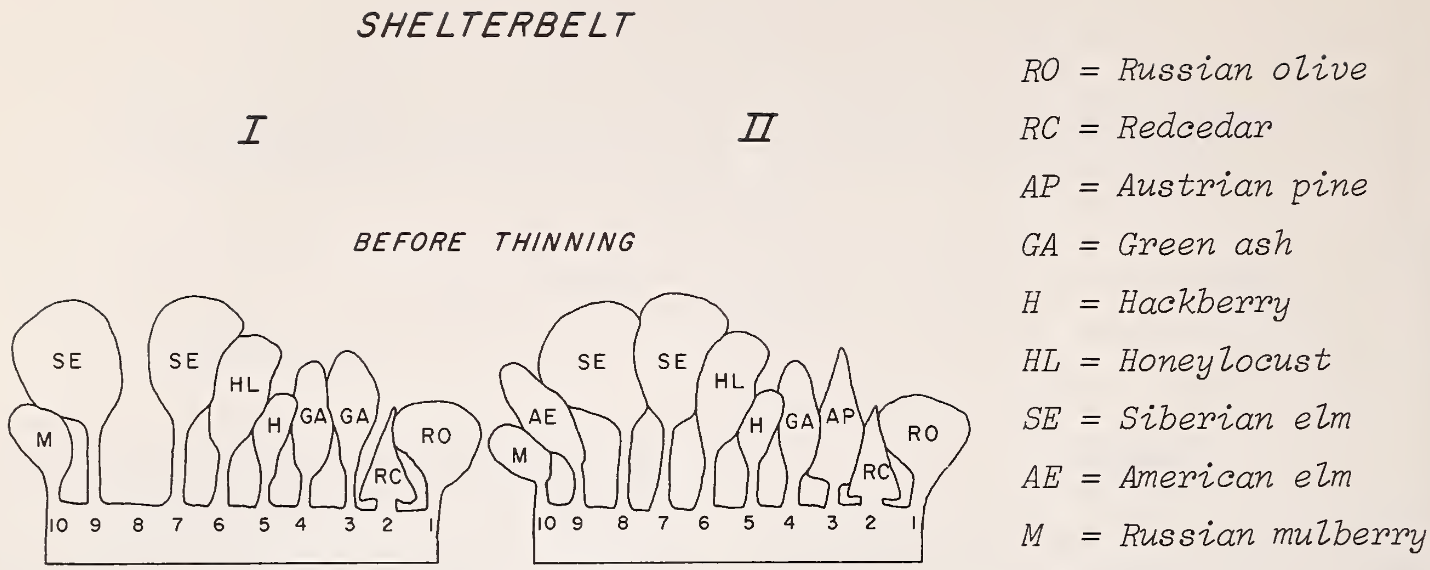


Figure 1.--Profiles of the two shelterbelts before treatment.

in diameter and height growth and crown spread in American elm, boxelder, and green ash following renewed cultivation in sod-bound shelterbelts.

Study Areas

Two shelterbelts in Seward County of eastern Nebraska were treated during the summer of 1960. The shelterbelts had been planted in the spring of 1940 under the Prairie States Forestry Project. They were privately owned, and situated on level upland sites of silty clay loam derived from loess. Average annual precipitation in this area is about 27 inches.

Each shelterbelt contained 10 rows of trees and shrubs. Their overall development had been similar, and both developed uniformly throughout their length. Rows were spaced 10 feet apart in both shelterbelts. The main differences between Shelterbelts I and II were species composition and within-row spacing (table 1, fig. 1). In Shelterbelt I, trees were spaced 8 feet apart within rows except for Russian-olive, redcedar, and mulberry, which were planted closer. All but a few of the cottonwoods had died during the drought of the early 1950's. Survival in the ash and hackberry rows was about 90 percent, and about 75 percent in Siberian elm and honeylocust.

While the interior rows in Shelterbelt II were also spaced 10 feet apart, initial spacing between trees within rows was but 6 feet in all rows from ash through American elm. Consequently, Shelterbelt II was somewhat denser, composed of trees with more compact crowns and generally smaller stems (table 1). Total mortality in Shelterbelt II was only slightly greater than in Shelterbelt I, despite the difference in growing space.

Treatments and Measurements

Treatments were: (1) release on two sides—removal of all trees in both rows adjacent to a row occupied by a study species; (2) release on one side—removal of trees in only one of the two rows adjacent to a study species; and (3) no release.

Row removal was selected over some method of selective thinning because:

1. Results would be simpler to evaluate.
2. It produces uniform changes in foliage density and barrier effectiveness throughout the treated segments.
3. It simplifies replanting and other cultural treatments.
4. It provides continuous openings, which may encourage more natural regeneration than isolated small openings.
5. It is compatible with schemes for reducing shelterbelt width.
6. It is a simple treatment to prescribe and apply.

Figure 2 illustrates the arrangement of treated segments in both shelterbelts. Each segment included 30 living trees of a given species, of which 20 were trees of record. The 20 record trees were divided into 2 subsegments of 10 trees each. The two subsegments were separated by a pair of "isolation" trees in the middle of the segment. There were also four "isolation" trees at both ends of each segment. Trees in the clearcut rows were cut near ground level with a chainsaw, and the slash was scattered in the rows not included in the study. Stump sprouts were allowed to develop naturally in one-half of each segment, while sprouting was prevented in the other half by spraying stumps with low-volatile 2,4,5-T in fuel oil.

Table 1. --Composition and arrangement of species in study shelterbelts, with measurements taken at time of treatments (rows numbered south to north)

Row No. (S-N)	Species	Height	Diameter	Crown length	Crown width (S-N)
		Feet	Inches	Feet	Feet
SHELTERBELT I (10 by 8 ft. spacing):					
1	Russian-olive *Eleagnus angustifolia* L.	--	--	--	--
2	Eastern redcedar *Juniperus virginiana* L.	--	--	--	--
3	Green ash *Fraxinus pennsylvanica* Marsh.	28.9	5.4	25.8	17.4
4	Green ash	29.4	4.3	17.4	11.0
5	Hackberry *Celtis occidentalis* L.	27.6	4.1	22.8	11.1
6	Honeylocust *Gleditsia triacanthos* L.	31.6	4.8	19.8	14.9
7	Siberian elm *Ulmus pumila* L.	36.2	6.9	26.8	14.1
8	Cottonwood *Populus deltoides* Marsh.	--	--	--	--
9	Siberian elm	36.2	7.2	29.8	20.4
10	Mulberry *Morus alba* f. *tartarica* Seringe	--	--	--	--
SHELTERBELT II (10 by 6 ft. spacing):					
1	Russian-olive	--	--	--	--
2	Eastern redcedar	--	--	--	--
3	Austrian pine *Pinus nigra* Arnold	--	--	--	--
4	Green ash	29.2	4.9	23.1	15.2
5	Hackberry	26.1	4.0	19.2	10.3
6	Honeylocust	31.3	4.1	18.4	13.4
7	Siberian elm	36.2	6.2	22.1	14.2
8	Siberian elm	35.9	6.5	20.1	14.3
9	American elm *Ulmus americana* L.	29.1	5.3	22.6	14.4
10	Mulberry	--	--	--	--

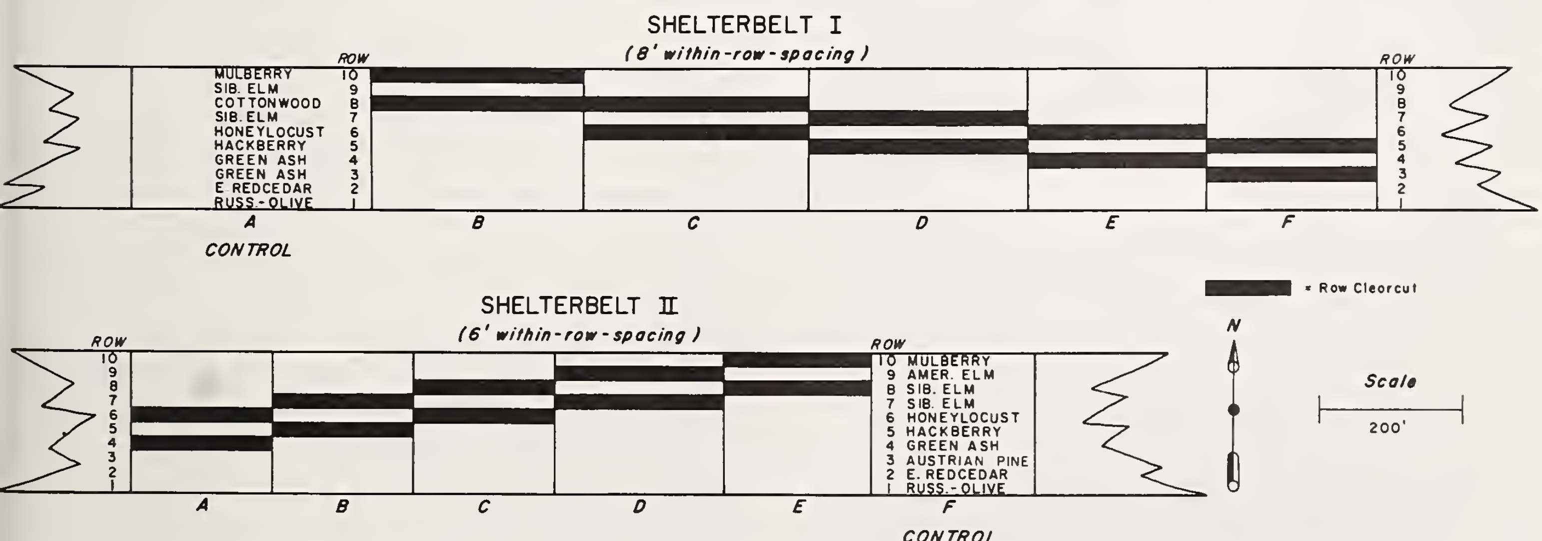


Figure 2.--Species associations, and relative size and arrangement of treated segments.

Stem diameters, total heights, crown lengths, and crown widths were measured every other year for 7 years following treatment. Sprout heights were measured on the same schedule. Photographs were taken periodically to record changes in stand structure and form.

Results and Interpretations

While identical treatments were tested in both shelterbelts, there was no true replication of treatments because of differences in stand composition, arrangement, and spacing. Consequently, treatment effects must be considered separately for each shelterbelt, even though trees of a given species may have responded similarly to the same treatments in both shelterbelts.

The lack of replication precluded the use of statistical tests in the evaluation of results. To provide some basis for objective judgments of significance, however, all mean values in the following graphs are supported by confidence intervals of plus and minus one standard error. The probability that the true mean of the population will fall within ± 1 standard error is 0.66. Despite some apparent overlapping of confidence intervals, the trends of response are clear and consistent enough in most instances to permit meaningful interpretations.

Stem Diameter Growth

Released trees generally grew faster in diameter than their unreleased counterparts, and in five rows out of nine, trees released on two sides grew faster than trees in the same row released on only one side (fig. 3). Throughout the tests, there appeared to be a logical, direct proportionality between changes in growth rates and changes in competitive stress produced by treatment.

Green ash responded with a meaningful increase in diameter growth only where it was released on two sides from crowding by other deciduous trees, however. It showed little growth increase after release on one side when adjacent conifers remained on the other side. Evidently, ash can compete well when adjacent to rows of pine or cedar, but not when located between rows of hardwoods.

Hackberry grows slowly when young, so it is often severely suppressed in the older shelterbelts. It proved exceptionally responsive to release in this study—trees released on one side added two to three times as much diameter increment as unreleased trees, and trees released on both sides added three to six times as much.

Honeylocust responded moderately to release, but release on two sides was no more beneficial than release on one side. The reason, of course, is that locust growth was not being influenced by the adjacent row of suppressed hackberry. The relatively good growth of unreleased locust suggests that it receives adequate sunlight from the south because of its dominance over hackberry.

Siberian elm responded more to release, relative to controls, in Shelterbelt II where spacings were closer and competition for growing space was more severe. In Shelterbelt I the Siberian elm trees were essentially free from crowding from between rows because of the relief from competition provided by the death of the cottonwood row between the elm rows some 15 years before. Thus, Siberian elm in row 7, Shelterbelt I, adjacent to and dominating the honeylocust, responded only slightly to the removal of thehoneylocust,that it was overtopping. Similarly, Siberian elm in row 9, Shelterbelt I, dominating the mulberry, apparently did not benefit from the removal of that suppressed row. Siberian elm in Shelterbelt II, however, did respond relative to the amount of release. While the total amount of diameter increase was greater in Shelterbelt I, the contrasts between treatments were greater in Shelterbelt II.

American elm also responded markedly to release, but removal of the adjacent row of Siberian elm on the south side was apparently as beneficial as removal of both the Siberian elm and the adjacent row of shorter and less competitive mulberry on the north side.

The consistently greater amount of diameter response in Shelterbelt II supports the earlier statement that the trees in Shelterbelt I were somewhat less crowded due to their wider within-row spacing. However, neither shelterbelt had stagnated.

While stem diameter is not, in itself, a factor in shelterbelt effectiveness, stout stems are needed to support the large crowns desired in shelterbelt trees. Also, the first evidence of loss of vigor or suppression is normally a tree-wide decrease in the production of secondary xylem (Bormann 1965), reflected in a slowdown in diameter growth. Consequently, treatment that improves a tree's growth status should accelerate diameter growth.

Height Growth

Except in those instances where trees were heavily suppressed, release produced no important improvement of height growth (fig. 4). This is consistent with the results of nearly all studies of thinning in natural forest stands.

Release did not improve height growth in either green ash or honeylocust. In some instances it appeared that the removal of adjacent rows of trees had caused a sagging of crowns into vacant rows, thus giving the effect of a net loss in total height. Green ash and honeylocust trees averaged 29 and 31 feet tall, respectively, at the time of thinning.

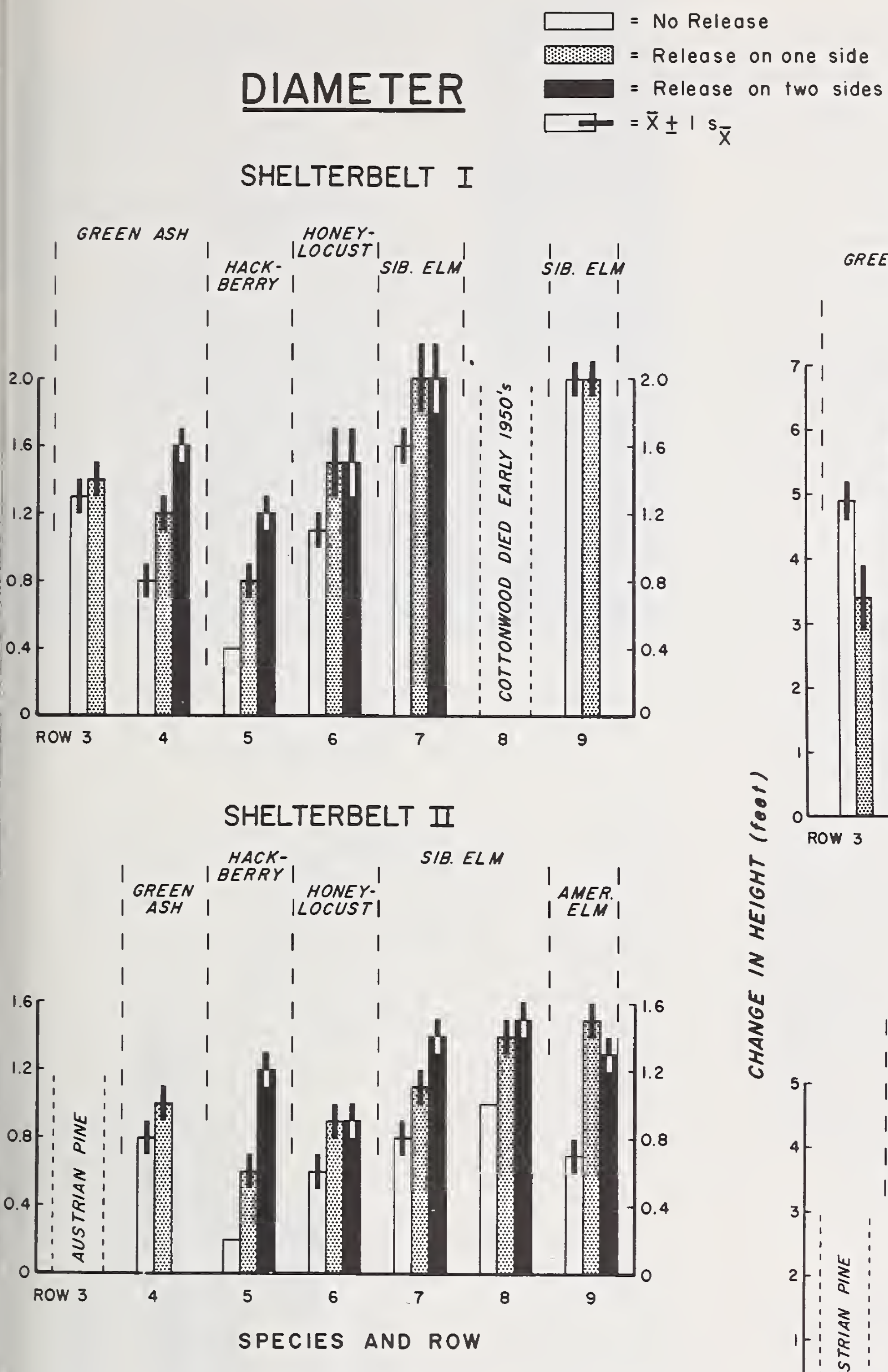


Figure 3.--Stem diameter growth of five hardwood species during a 7-year period following release.

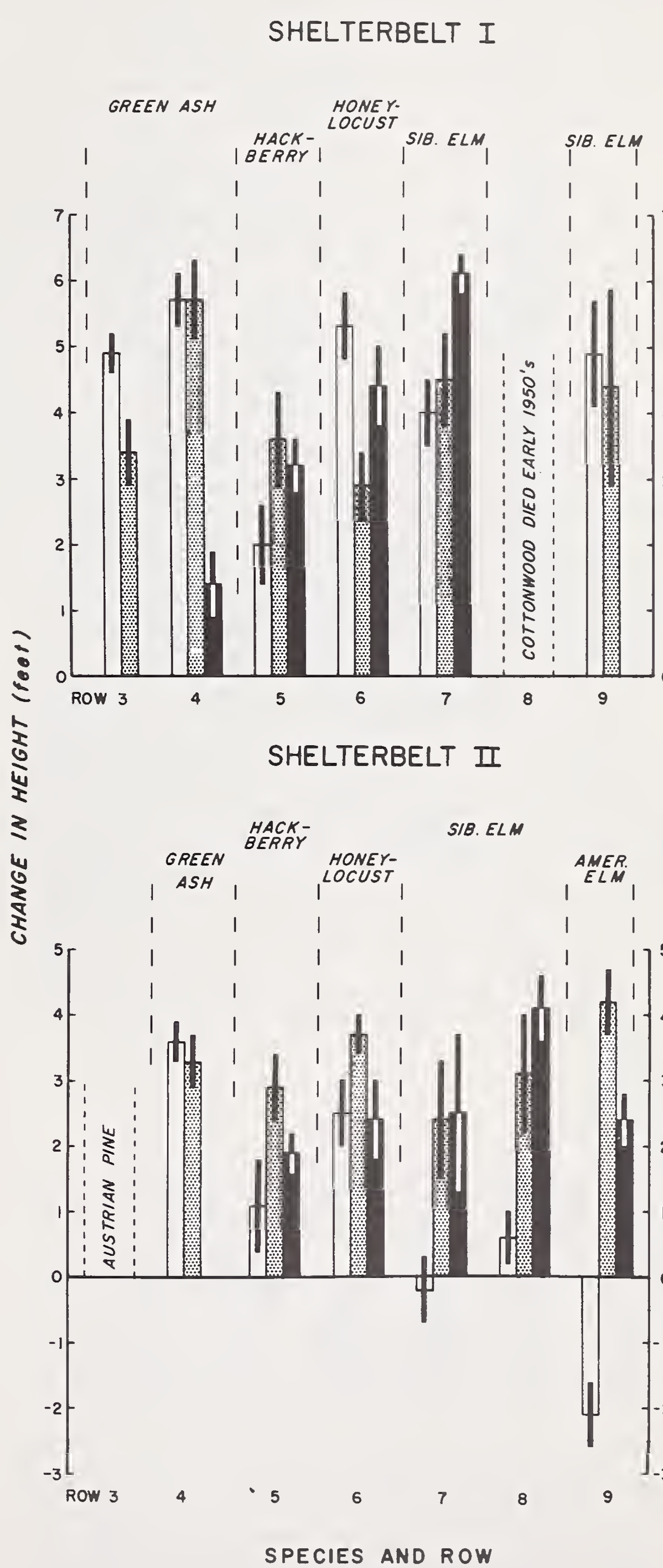


Figure 4.--Height growth of five hardwood species during a 7-year period following release.

Hackberry, on the other hand, increased substantially in height growth following release in both shelterbelts. The gains further demonstrate the ability of badly suppressed hackberry to respond to increased growing space. Average heights of hackberry trees were 26 and 28 feet at the beginning of the study in Shelterbelts I and II, respectively. Thus, they were some 2 feet shorter than the adjacent green ash trees to the south and nearly 4 feet shorter than the honeylocust trees to the north.

In general, height growth of Siberian elm also improved. This species grows rapidly and, presumably, is capable of quicker response to release than some of the slower growing species. An exception was the Siberian elm in row 9 of Shelterbelt I. Here, the elm was so dominant over the adjacent row of mulberry that it received no stimulus from mulberry removal.

While the total response in Siberian elm was greater in Shelterbelt I, responses were greater relative to the controls in Shelterbelt II where growing space was more limited and where the two adjacent rows of Siberian elm were in direct competition with one another for moisture and light. Siberian elm had an average height of about 36 feet in both shelterbelts, which placed it in a dominant position over adjacent species.

American elm was severely suppressed before release, and this was reflected by the response to thinning. This species was, for the most part, overtopped by Siberian elm and in total shade most of the day. Its average height was only about 28 feet. Control trees lost about 2 feet of height during the study period. Removal of Siberian elm on the south side only apparently accounted for the bulk of the response—more than 6 feet over the control trees. American elm in turn was dominant over the outside row of mulberry. Its response to the removal of the mulberry was negligible.

Crown Length

While release did not greatly increase height for most trees, it did have a striking influence upon crown development (fig. 5). Removal of row segments "opened up" the shelterbelts and greatly increased the amount of sunlight, soil moisture, and growing space available per tree. Exposure stimulated adventitious buds on the lower stems of the study trees which quickly developed into branches. When the branches exceeded one-half inch in diameter, they were considered to be components of the crown. With the exception of green ash adjacent to the conifer row (1, row 3) all species responded to treatment with some measurable increase in crown length. Honeylocust, Siberian elm, and hackberry (fig. 6) developed the most epicormic branches. Epicormic branching, which increases lower level foliage density, may prove to be one of the most important benefits of release treatment.

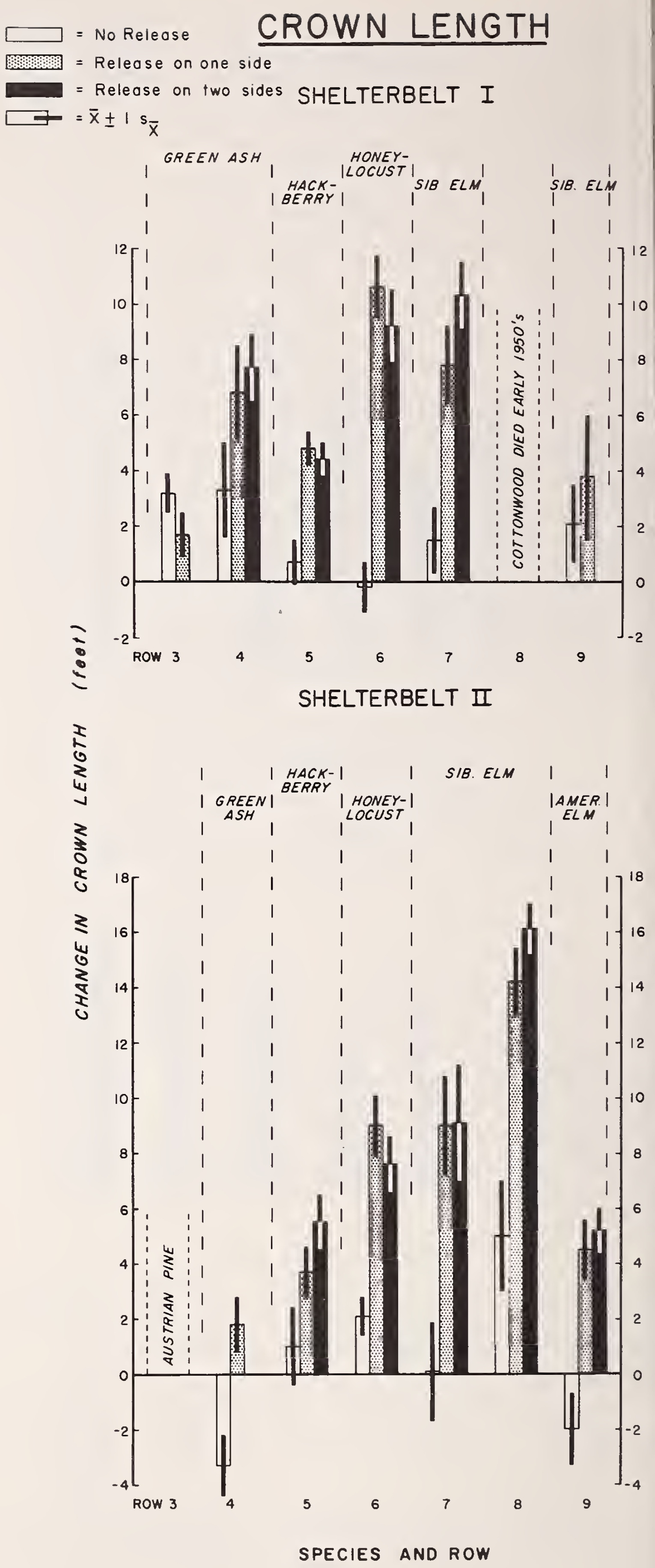


Figure 5.--Effect of release on length of crown of five hardwood species in shelterbelts during a 7-year period.

ure 6.--Epicormic branches developed from adventi-ious buds on stem of hackberry, 7 years after re-ease. The visible portion of stem pictured had no ive branches at time of release. (Scale = 1 sq. t. per block).

Crown lengthening tended to be related to degree of release, but was also influenced by the amount of crowding prior to treatment, by row position, and by species association within the shelterbelts. The small increases in crown length of trees in the control segments during the study period emphasizes the crowding and shading in the lower levels of these overstocked shelterbelts. In most control trees, die-off of basal branches was rapid enough to offset additions to crown length provided by height growth, especially in Shelterbelt II (see rows 4, 7, and 9.)

Crown Width (Between Rows)

Study trees responded to release by expanding their crowns laterally to occupy vacant space provided by the removal of adjacent rows (fig. 7). Amount of crown expansion appeared to be roughly related to degree of release and to the condition of the trees prior to thinning. For example, the green ash adjacent to rows of conifers (I, row 3; II, row 4) failed to expand their crowns just as they failed to increase in diameter, height, or crown length. On the other hand, the more heavily suppressed trees (green ash in I, row 4, and hackberry and honeylocust in both shelterbelts) spread their crowns vigorously—especially when released on both sides. Siberian elm responded less consistently, presumably because of variable competition within the elm rows. American elm in Shelterbelt II also increased in crown width, although the increases over the controls were not large. Reclosure of the crowns following release is apparent in figures 8 and 9.

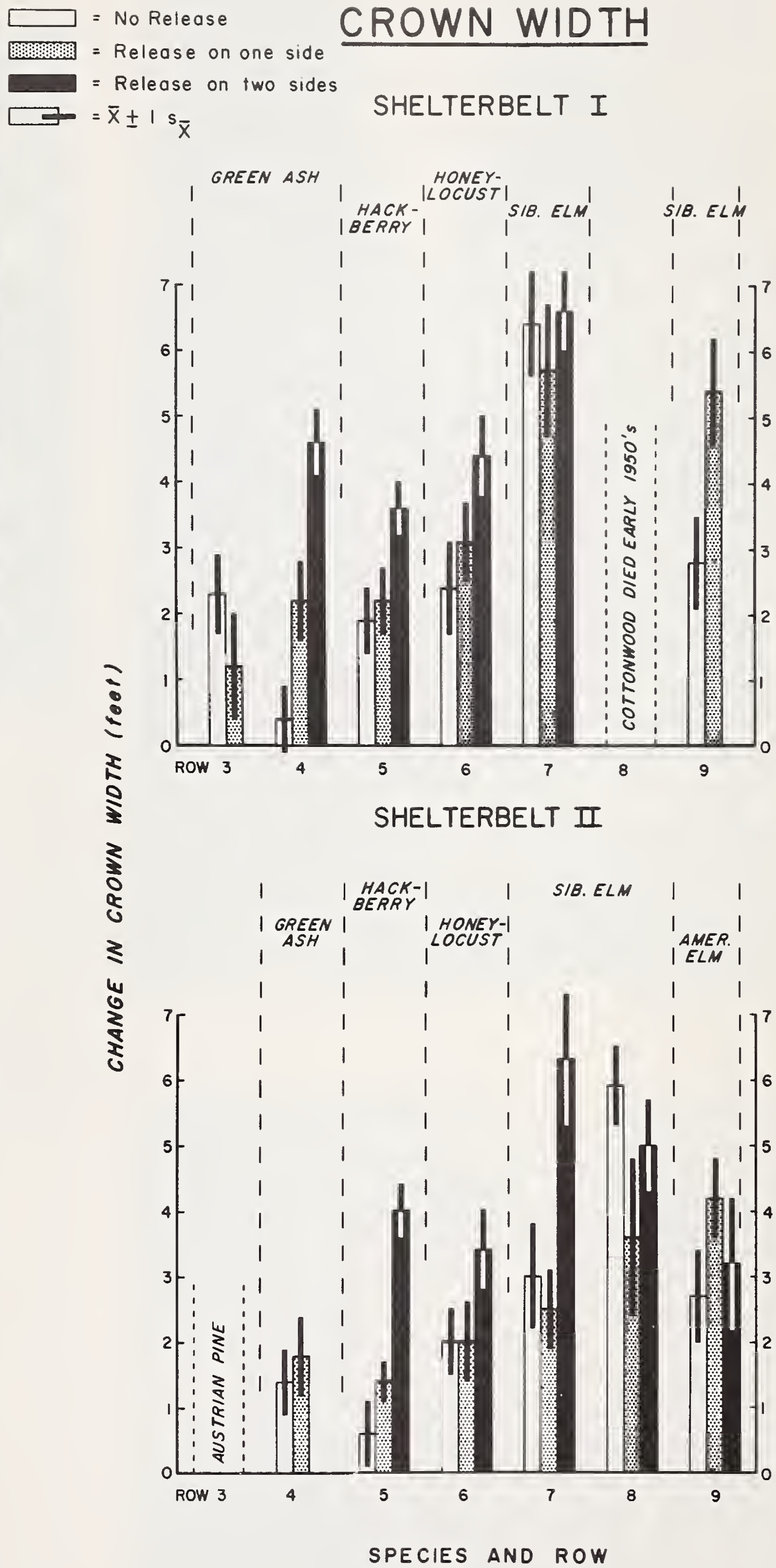


Figure 7.--Crown width responses of five hardwood species during a 7-year period following release.

Figure 8.--Successive changes in crown development of green ash (left) and honeylocust (right) after removal of hackberry (center) and green ash row (far left). Note increase of weed cover in foreground where sprouts were not allowed to develop(B and C). Hackberry sprouts are developing in center background (B and C).

A, 1960

B, 1962

C, 1967

A, 1960

B, 1962

Figure 9.--After rows were removed, crowns closed progressively due to increased crown length and width, increased foliage density, and sprout development. Siberian elm (left foreground and left rear) honeylocust (center) and hackberry (right foreground). Hackberry sprout visible to right of segment identification card in C.

C, 1967

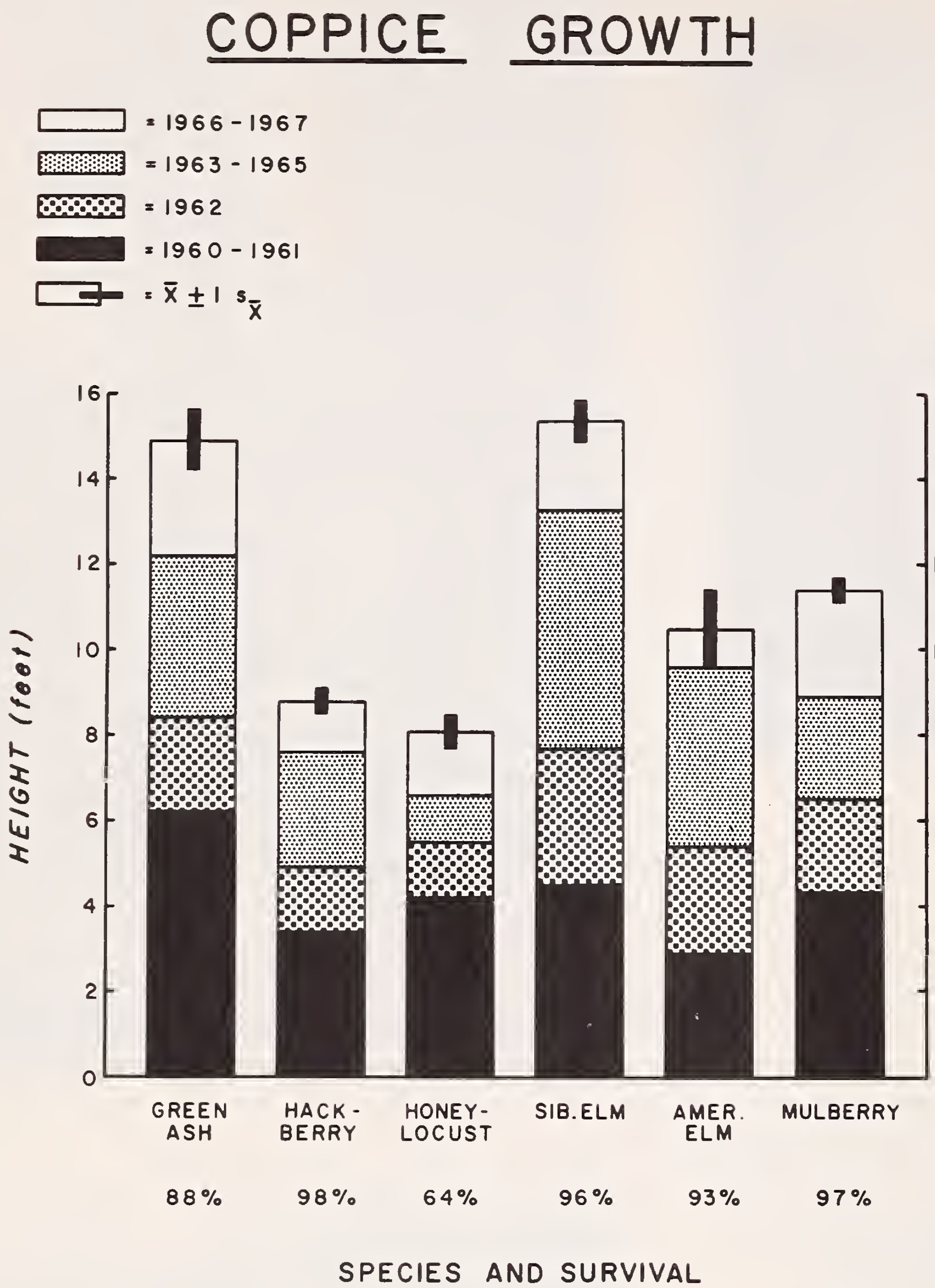


Figure 10.--Cumulative growth of sprouts of six hardwood species cut to relieve crowded conditions in shelterbelts.

Stump Sprouts and Ground Cover

Sprouts from the stumps of cut trees has also contributed to rapid restoration of lower level density in these shelterbelts. This is desirable during the first years after treatment while residual trees are gradually filling out their crowns and increasing their foliage density.

Siberian elm and green ash were the most vigorous sprouters (figs. 10, 11). Their sprouts attained heights of about 15 feet by the end of the study period. American elm, hackberry, and mulberry sprouts also developed vigorous, bushy clumps averaging about 10, 9, and 8 feet high, respectively. Mulberry sprouts provided increased density at levels slightly lower than that of Siberian elm and green ash. Survival of sprouts was excellent for all of the species mentioned above—all exceeded 90 percent. Honeylocust sprouts, however, did not develop vigorously, probably because of relative intolerance to shade. Honeylocust sprout clumps were neither vigorous nor dense, and only about two out of three clumps survived at the end of the study period.

Grass and weeds invaded those portions of row segments where the tree stumps had been killed to prevent sprouting (fig. 8). Grass and weed cover remained light, however, where sprouts were allowed to develop.

Development of dense stands of herbaceous ground cover may be undesirable, since it can compete with trees (Phipps 1963). Stump sprouts may be equally competitive. Since sprouts contribute more than grass and weeds to the restoration of low-level protection, sprouting should be encouraged. As the residual trees gain vigor and the crowns again close (figs. 8c and 9c) the grass and weed cover will undoubtedly decline, and the sprouts will tend to become leggy and sparse. Stump sprouting provides the forester with a measure of control, in that he can choose the kind and amount of sprouting to suit his needs.

Figure 11.--Sprouts from stumps of green ash trees, 7 years after cutting. Sprout clumps improve foliage density at lower level and discourage grass invasion while residual trees respond.

Seedling Reproduction

In certain areas of the shelterbelts, mainly on the outside rows, row removal creates excellent conditions for volunteer tree seedlings. Siberian elm seedlings were about 9 feet tall 7 years after release treatments were applied. The densities and vigor of these volunteer seedlings tend to be lower in interior row segments. They are even less numerous and vigorous in segments containing stump sprouts.

Application

The general condition of the study shelterbelts would have been better if periodic thinnings had been started in these heavily stocked plantings at about age 10 to 12, or earlier for the coniferous components. However, these results clearly show that even at 20 years of age, thinning pays big dividends in increased growth and vigor, thus enhancing the effectiveness and probably the longevity of shelterbelts.

Based on results of row release in the two study shelterbelts, and related research results, the following recommendations seem justified (fig. 12):

Clearcut hardwood rows adjacent to conifers (Examples: I, rows 1 and 3; II, rows 1 and 4).

Hardwood trees adjacent to conifer rows are usually restricting conifer development. The exterior row should be cut and the stumps poisoned. The interior row should be allowed to sprout for several years until the conifers can again provide year-round protection (Van Haverbeke and Boldt 1968).

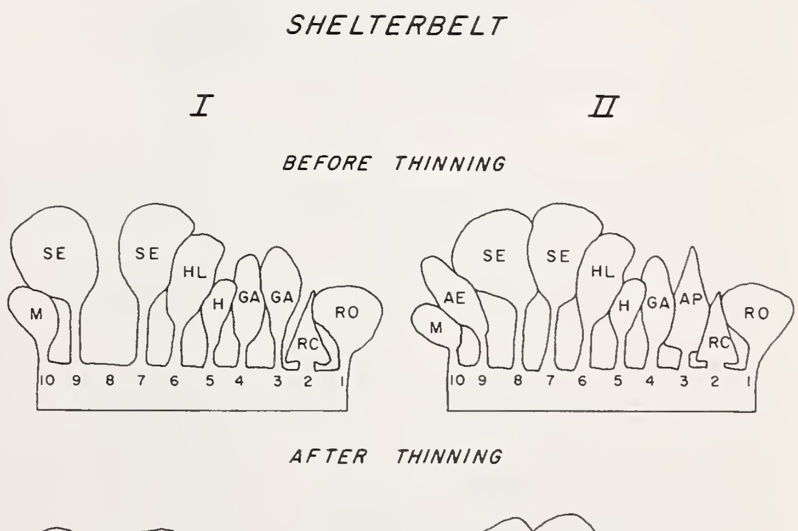
Clearcut green ash on south side of hackberry where possible (Example: II, row 4).

Hackberry is a desirable species to save in most shelterbelts. It has usually survived well despite intense crowding, and it may be expected to respond well to release. Hackberry is also relatively free from damaging insects and diseases. The green ash sprouts should be allowed to develop for a number of years. Although within-the-row thinning was not a part of this study, it is recommended that low-vigor, stunted hackberry trees also be cut and allowed to sprout.

Selectively thin hackberry and green ash (Examples: I, rows 4 and 5).

In shelterbelts where hackberry is the third row from the conifer row, removal of both intervening rows between the hackberry and conifer—one to free the conifers and the other to free the hackberry—is not recommended. This would create an excessively wide intervening strip and encourage the invasion of grasses and weeds. It would be best to clearcut the green ash row adjacent to the conifers, and selectively thin the hackberry and its adjacent row of green ash, with subsequent sprouting of all cut trees. Thinning should remove overtopped and suppressed trees in both rows, along with some dominant trees. Selective thinning should alleviate crowded

Figure 12.--Application of treatment recommendations to Shelterbelts I and II.



conditions in both rows, provide needed intermediate density until the residual trees have responded to thinning, keep the spacing between the conifer row and hackberry reasonable, and restrict invasion of weeds and grasses.

Clearcut honeylocust (Examples: I and II, row 6).

Clearcutting and sprouting of honeylocust is recommended to add to the response of hackberry and improve vigor of the adjacent row of Siberian elm (row 7). In time, the increased height growth of the hackberry and the increased crown length and foliage density of both hackberry and Siberian elm should compensate for any loss of intermediate-level density formerly provided by the honeylocust. While honeylocust does not sprout vigorously, its sprouts will help hold grasses and weeds in check.

Selectively thin Siberian elm (Examples: I, rows 7 and 9; II, rows 7 and 8).

In the absence of cottonwood, Siberian elm is usually the tallest species in most older shelterbelts. It is usually in a dominant position, and it may have already benefited on upland sites from death of the cottonwood (Shelterbelt I). This study suggests that Siberian elm benefits as much from release from competition with its own kind as from other species. Therefore, a selective thinning within the rows of Siberian elm — to remove weak and overtopped trees—is recommended. The same treatment would be advisable where two or more Siberian elm rows are adjacent (Shelterbelt II). Elm sprouts would provide intermediate density until the crowns of the residual elm trees fill out.

Clearcut American elm (Example: II, row 9) and mulberry (Example: I and II, row 10).

American elm is apparently contributing very little to the effectiveness of most shelterbelts—at least when it is situated as in Shelterbelt II. Thus, American elm and the outside row of mulberry could be clearcut, and either or both species allowed to sprout into low-level shrub rows.

Any or all combinations of these recommended treatments could be applied in shelterbelts similar to those in this study. They can be applied either in one operation or in a step-wise manner where the need is to improve overall effectiveness of the shelterbelt. Where it is desirable to reduce the width of an existing shelterbelt, those interior rows of the shelterbelt to be retained should be released first. Later, after the released trees have improved in growth and vigor, the unwanted exterior rows may be cut.

It should be noted that all recommendations are based on work in shelterbelts oriented east-west, with conifers on the south side. The same treatments might produce somewhat different results in shelterbelts oriented or arranged in other ways.

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*Address requests for copies to originating office.

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1969. Release benefits hardwoods in crowded shelterbelts. U.S.D.A. Forest Service Research Paper RM-46, 12 pp., illus. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado 80521.

Rows of green ash, hackberry, honeylocust, Siberian elm, and American elm trees were released in 1960 after nearly 20 years of crowding in two Nebraska shelterbelts. Treatments were: clearcutting two adjacent rows, clearcutting one adjacent row, and no cutting. Results were studied for 7 years. Released trees grew faster in diameter and height, and developed longer, wider, denser crowns than unreleased trees. Epicormic branches on stems of released trees, together with sprouts from stumps, helped restore low-level densities and restricted the invasion of grass and weeds.

Key words: Shelterbelts, hardwoods, Nebraska

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